

**ROLE OF WAVELENGTH-SPECIFIC REFLECTANCE
INTENSITY IN HOST SELECTION BY
HETEROPSYLLA CUBANA CRAWFORD
(HOMOPTERA: PSYLLIDAE)**

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Abstract. — In a field experiment in the Philippines, “super yellow” card traps reflecting maximally at 500–550 nm attracted significantly more adults of the exotic psyllid, *Heteropsylla cubana* Crawford, than cards reflecting maximally above 600 nm or below 500 nm. This peak reflectance corresponded to the maximal reflectance from the psyllids’ preferred site of alightment, the young expanded leaves of the leguminous tree, *Leucaena leucocephala* (Lamarck) de Wit. The high reflectance intensity (RI) of super yellow cards compared to the lower RIs of less preferred yellow cards suggest that both wavelength and intensity of reflected light influence responses of *H. cubana* to its host tree. The relatively low trap catches compared to the population in the field, and the pronounced orientation observed in previous experiments to the odor of visually-obscured *L. leucocephala* seedlings, suggests that olfaction is more important than vision in host selection by *H. cubana*.

Key words. — Insecta, *Heteropsylla cubana*, *Leucaena leucocephala*, host selection.

Host selection by phytophagous insects is governed by physical and chemical characteristics of their host (Harris & Miller 1983, Owens & Prokopy 1986, Nottingham 1987, Thiery & Visser 1987). Many studies have demonstrated that insects are highly discriminating while foraging for food or oviposition sites using visual or olfactory stimuli (Todd et al. 1990, Aluja & Prokopy 1993).

Of the potential visual cues, color is the most studied. Most insects respond positively to spectral reflectance ranging from 350–650 nm (Menzel 1979). Caribbean fruitflies, *Anastrepha suspensa* (Loew), are attracted by orange and yellow, the colors of many fruits that they attack (Greany et al. 1977). Initial landings of the aleyrodid, *Trialeurodes vaporariorum* Westwood, appear unrelated to the suitability of the plant as a host, but are strongly related to color (Vaishampayan et al. 1975). In their flight phase, adults orient towards the sky which reflects at 400 nm but tend to land on green plants that reflect maximally at 550 nm (Coombe 1982). Whiteflies and aphids show strong landing responses to yellow-reflecting surfaces (Kring 1972), as in green leaves that reflect peaks in the yellow portion of the visible light spectrum.

Following its introduction into many South Pacific and Southeast Asian countries, the psyllid, *Heteropsylla cubana* Crawford, a native of Central America, has killed and severely debilitated *Leucaena leucocephala* (Lamarck) de Wit, a le-

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guminous tree of major economic and social importance (Chouinard 1983). One possibility for the resurrection of *L. leucocephala* as a significant species for forestry and agro-forestry is the development of resistance to the psyllid (Sorensson & Brewbaker 1986, 1987). Lapis & Borden (1992) found that on *L. leucocephala* the psyllid caused far less height growth, lateral growth, and biomass accumulation than on a resistant species, *L. collinsii* Britton & Rose. Lapis & Borden (1993a) observed an olfactory preference by the psyllid for the former over the latter species. Moreover, on *L. collinsii* there was 46–63% less oviposition, 67% lower nymphal survival, smaller adult size, and in total > 90% fewer adults produced than on *L. leucocephala* (Lapis & Borden 1993b).

To date, no research has addressed the role of vision in host preference by *H. cubana*. Our objective was to determine if color could influence the differential preference displayed by *H. cubana* adults for *L. leucocephala* over *L. collinsii*.

MATERIALS AND METHODS

Chrome-line card traps, 10 × 15 cm (Phero Tech Inc., Delta, B.C.) of the following colors were compared for their relative attractiveness to adult *H. cubana* in the field: non-UV white, blue, bright yellow, orange yellow and super yellow, which is fluorescent. Visible wavelength reflectance curves for the five colored board traps are shown in Fig. 1. The differently colored cards were randomly hung vertically, evenly spaced 0.6 m apart, from a horizontal string suspended 1.5 m above ground and approximately 1 m away from the nearest vegetation inside an infested stand of *L. leucocephala* in Los Baños, Philippines. The stand was dominated by coppiced trees approximately 2 m high with a sparse overstory of trees 6 m high. After 24 h, the traps were collected and the numbers of captured adults were counted under a dissecting microscope. The experiment was replicated 36 times over nine days, with four randomized block replications per day. In five of these days, the numbers of males and females caught were also counted separately.

Reflectance measurements on leaves of the two *Leucaena* spp. were made using a Cary 17 recording spectrophotometer on leaves laid side by side, but overlapping to provide a suitable reflecting surface, i.e., 15 unexpanded young leaves, seven fully expanded leaves just proximal to the unexpanded leaves, and three mature leaves two positions proximal to the latter. Each leaf for the composite sample was taken from a different plant. The side by side leaves were immobilized between 24 × 50 mm glass slides. Only the upper leaf surface light reflectance was measured. The reflectance intensities (RI) of visible light (350–700 nm), the total light of a specific or defined band of wavelengths reflected from the leaf surfaces (Vernon 1986), were compared with a magnesium oxide standard curve (= 100% reflectance). The same standard was used to derive the curves in Fig. 1.

The trap catch data were transformed using $\sqrt{(x + 0.5)}$ and the data for all the experimental days were tested for homogeneity of variance before analyzing the means by ANOVA and Duncan's multiple range test (Gomez & Gomez 1984). Data on response to color by sex were tested for homogeneity of ratio before testing by χ^2 for a fixed-ratio hypothesis.

RESULTS

Flying adult *H. cubana* showed a hierarchical preference for card traps colored super yellow, orange yellow, bright yellow, white and blue, in descending order

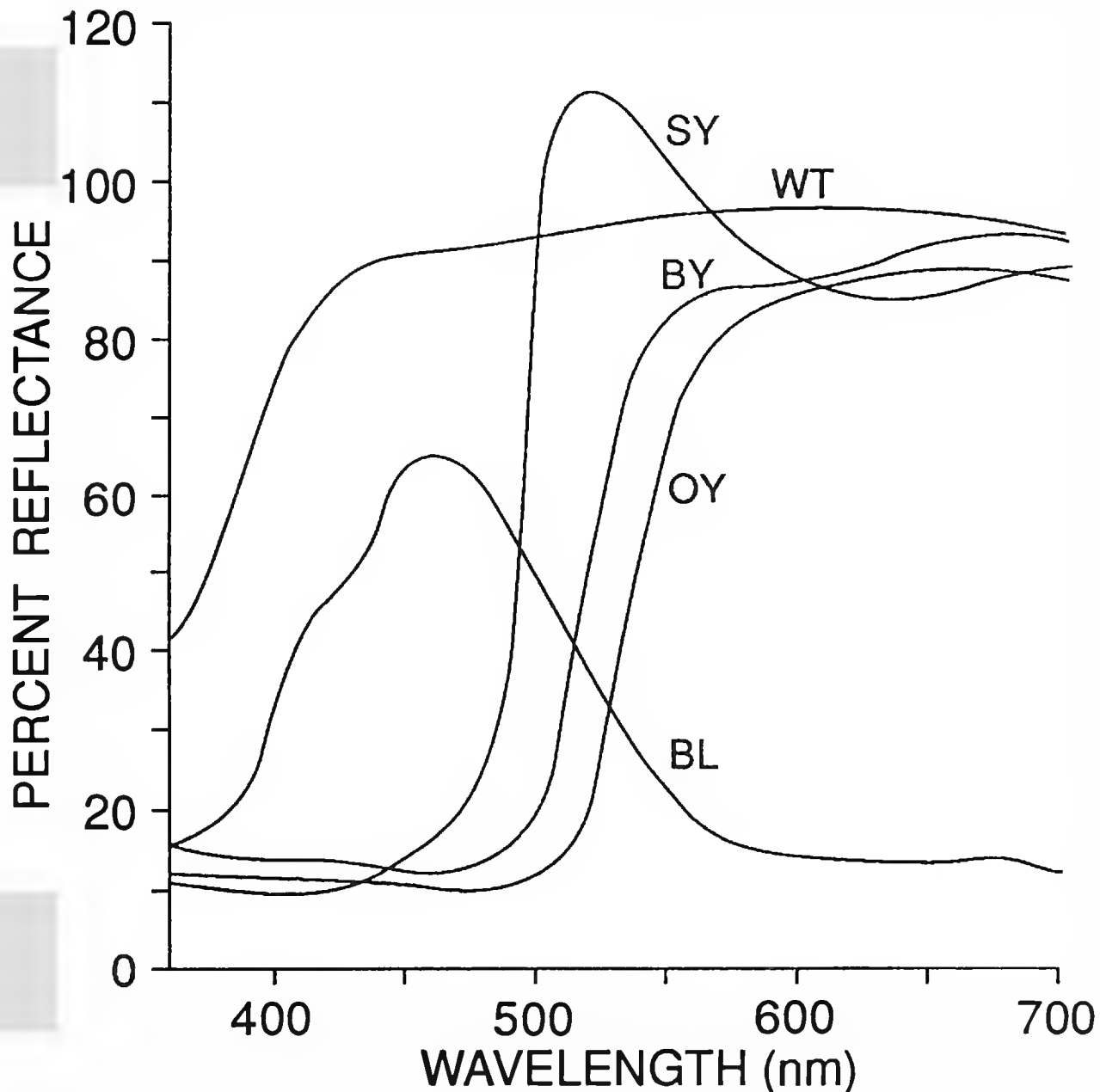


Figure 1. Spectral reflectance curves of 5 Chrome-line card traps; SY = super yellow, WT = non-UV white, BY = bright yellow, OY = orange yellow, BL = blue. Data obtained from Phero Tech Inc., Delta, B.C.

(Fig. 2). There were no significant differences in the responses of males and females to the different colored traps (χ^2 , $P > 0.05$).

The reflectance intensities (RI) of the leaves differed between ages and between *Leucaena* spp. (Fig. 3). The fully expanded leaf of *L. leucocephala* had the highest overall RI of 51%, followed by the unexpanded leaf at 47%. In comparison, the maximum RI of the fully expanded young and unexpanded leaves of *L. collinsii* were 46.5% and 46% respectively, slightly lower than that of *L. leucocephala*. The mature leaf of *L. collinsii* had a maximum RI of 41.5%, higher than that of *L. leucocephala* at 34%.

Leaves of all ages of both species reflected maximally at similar wavelengths, i.e., 550 nm (yellow). There was a pronounced rise in reflectance beginning at about 500 nm (Fig. 3), coinciding with a steep rise in reflectance of the most preferred super yellow cards (Fig. 1). The rise in reflectance at 500 nm was steeper and the peak at 550 nm was higher in the most vulnerable young leaves of *L. leucocephala* than in those of *L. collinsii* (Fig. 3). As the leaves matured, the yellow peak became less pronounced.

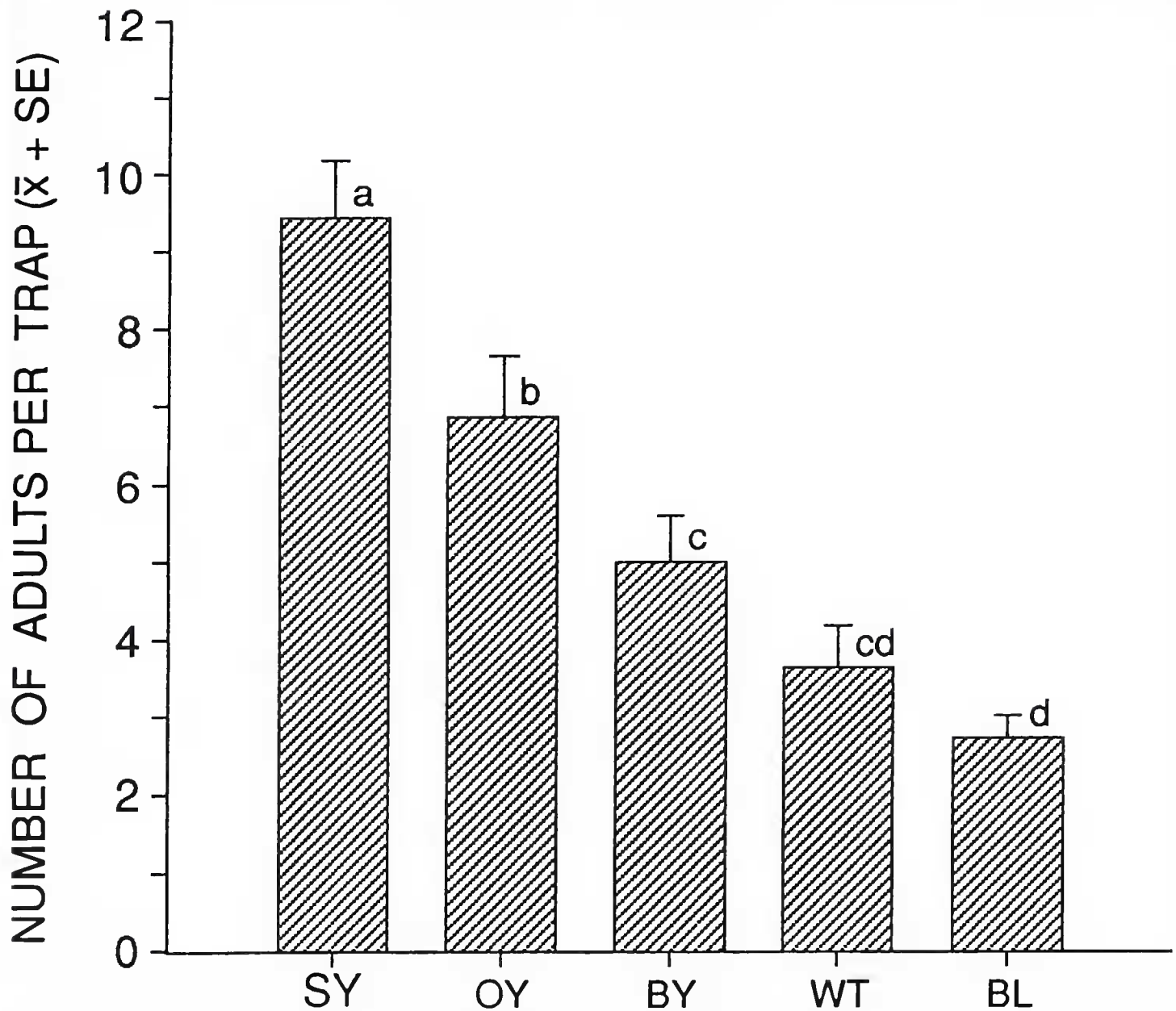


Figure 2. Numbers of adult *H. cubana* caught on colored Chrome-line card traps of different light reflectances. Bars topped by the same letters are not significantly different, Duncan's multiple range test, $P < 0.05$. (SY = super yellow; OY = orange yellow; BY = bright yellow; WT = non-UV white; BL = blue).

DISCUSSION

Our results suggest that both wavelength-specific (color) preference and reflectance intensity (RI) influence the attraction of *H. cubana* in the field (Figs. 1–3). Traps of yellow hue were preferred by adult *H. cubana* compared with blue and white, but maximum preference (Fig. 2) occurred for super yellow at 510 nm with the highest RI of 110% (Fig. 1). In the onion maggot, *Delia antiqua* Meigen, Ishikawa et al. (1985) found vivid yellow (572 nm), with a RI peak of 40% to be six times more attractive than pale yellow (576 nm), with a RI peak of 20%. Vernon (1986) showed violet or blue (400–470 nm) with a peak RI above 30% to be much more attractive to *D. antiqua* than the same spectral wavelength below a RI of 30%. This could explain, in part, why alighting adult *H. cubana* congregate on the young leaves and shoots of leucaena, which have higher RI than old mature leaves (Fig. 3). Prokopy & Owens (1983) noted that some aphids are most attracted to highly reflective young developing leaves, and brightness has also been demonstrated to be a key factor in the positive responses to color by grasshoppers

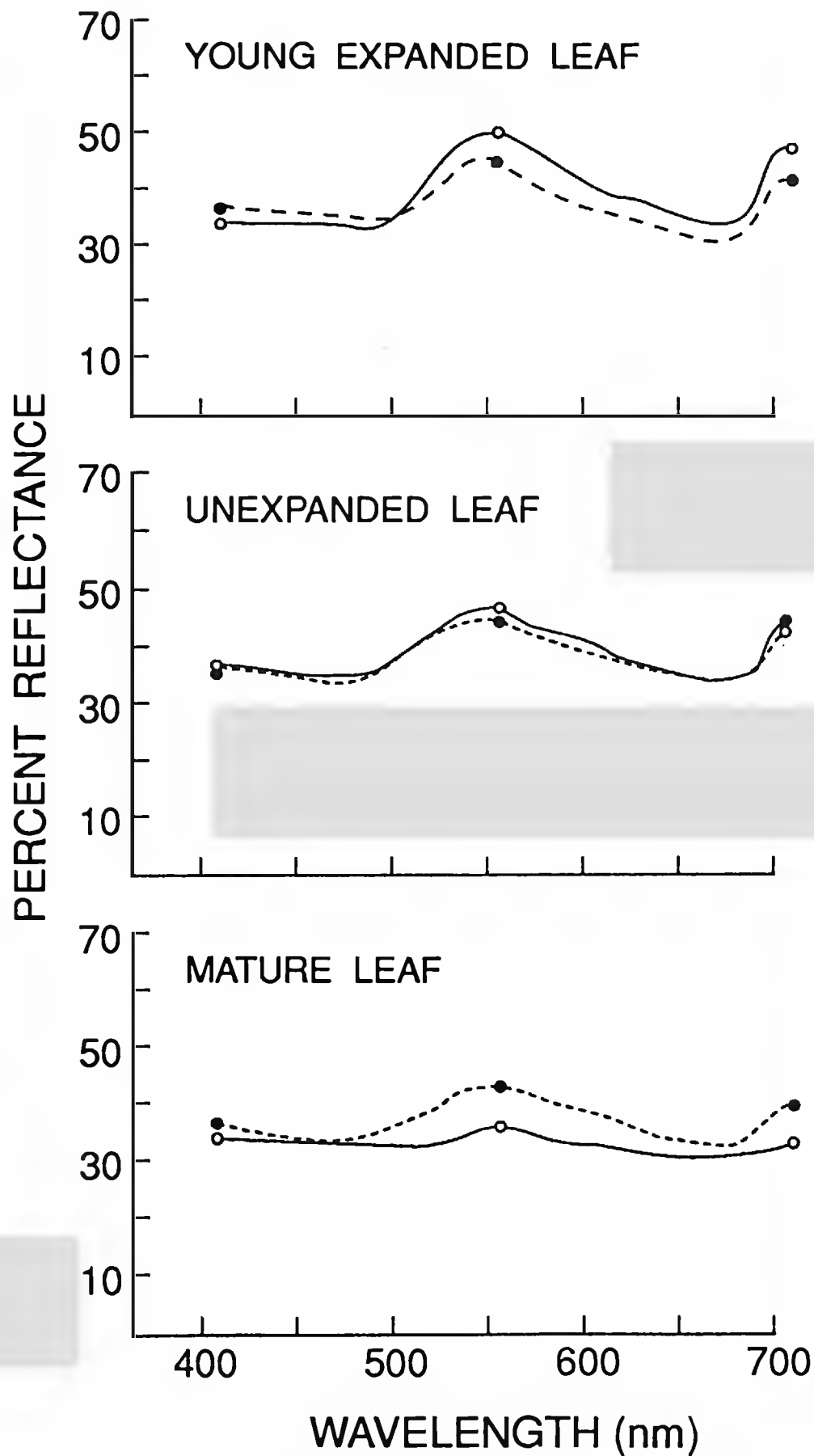


Figure 3. Spectral reflectance curves of young-expanded, young unexpanded, and mature leaves of *L. leucocephala* (solid line) and *L. collinsii* (dashed line).

(Kong et al. 1980) and the cabbage maggot, *Delia radicum* (L.) (Dapsis & Ferro 1983).

It is surprising that relatively few adults were caught on the traps when there were thousands of adult psyllids on the host trees during the experiment. The low numbers of captured *H. cubana* may be due to the small number of adults dispersing during the experiment. Moreover, those that were caught were flying within

the host canopy and probably did not easily distinguish between the cards and the foliage. For aphids, Kennedy et al. (1961) suggested that the primary function of plant color is to distinguish plants from the sky. They found that the predominantly long-wave emission from both leaves and soils (= 540–560 nm) contrasts sharply with shorter wavelengths of the light from clear or clouded skies (< 500 nm). Coombe (1982) showed that the whitefly, *T. vaporarorium*, is more likely to take off when illuminated with shorter (400 nm) than longer (550 nm) wavelengths, which stimulate the whiteflies to land (Coombe 1981). Even to the human eye, the young expanded leaves of *L. leucocephala* are more yellow in color than those of *L. collinsii*, while mature leaves of *L. leucocephala* appear to be darker green than those of *L. collinsii*. Thus the reflectance of young expanded leaves, which peaked at about 550 nm (Fig. 3) probably allows alighting psyllids to distinguish between species, as well as to avoid older leaves. The reflectance of shorter wavelengths from older leaves could have interfered with a landing response. This hypothesis would explain the low response to white and blue cards (Figs. 1, 2). Similarly, Judd et al. (1988) found ultraviolet reflectance to interfere with response by *D. antiqua* to reflectance between 350 and 400 nm.

The low numbers of adults caught suggest that color is a weak stimulus for host selection by *H. cubana*, and that other stimuli (e.g., host odor) play a greater role. Beck (1965) concluded that color by itself probably does not account for an insect's host specificity, although it frequently influences early stages of orientation to the host. In addition, Thorsteinson (1960) found shape, size and color to be "too variable and lacking the identifiable uniqueness required to explain the obvious discriminatory power of insects." The superiority of odor over color in host selection by *H. cubana* was demonstrated in an experiment in which plants were caged outdoors in such a manner as to obstruct color perception by the psyllids. In this experiment adult *H. cubana* preferentially oriented in large numbers to cages containing the more susceptible *L. leucocephala* than to cages holding either the less susceptible *L. collinsii* or a non-host leguminous plant (Lapis & Borden 1993a). Prokopy & Owens (1983) cautioned that plant spectral quality is unlikely to constitute a host-plant specific character for herbivorous insects because of its similarity among most plants, with some exceptions, e.g., red and green cotton plants (Stephens 1957), red and green Brussels sprouts (Dunn & Kempton 1976) and red and green cabbage (Prokopy et al. 1983). Because of its ability to discriminate between colors (Fig. 2), *H. cubana* likely uses both color and odor in locating its preferred host, *L. leucocephala*.

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